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(71) Applicant *(for all designated States except US)*: GRAPHIC UTILITIES, INC. [US/US]; Suite L, 2149 O'Toole Avenue, San Jose, CA 95131 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: CRYSTAL, Richard, G. [US/US]; 1091 Nottingham Way, Los Altos, CA 94024 (US). VARGAS, Herbert, Daniel, III [US/US]; 4700 Stratford Avenue, Fremont, CA 94538 (US). KARLSSON, Sven [US/US]; 5309 Roxanne Drive, San Jose, CA 95124 (US).

(74) Agents: DULIN, Jacques, M. et al.; Oblon, Spivak, McClelland, Maier & Neustadt, P.C., Crystal Square Five, 4th floor, 1755 Jefferson Davis Highway, Arlington, VA 22202 (US).

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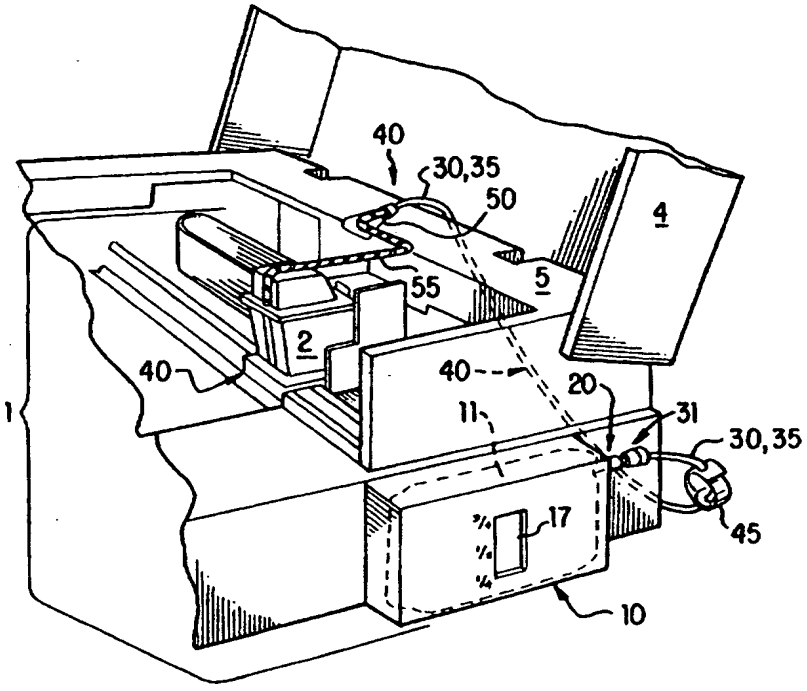
(54) Title: AUXILIARY INK RESERVOIR AND FEED SYSTEM AND METHOD FOR INK JET CARTRIDGES

(57) Abstract

Auxiliary ink feed system for ink jet printers, plotters, copiers, and faxes comprising an external auxiliary feed tank (10), a feed line (30) having anti-kink coil wrap (35) and a means for delivering ink into the cartridge (2) via the vacuum check valve (bubble former) in the bottom of the cartridge (2). The fitting for feeding to the check valve is preferably a lay-flat bag having double-sided tape to secure it to the bottom and back of the cartridge (2). Alternately, an adhesively-adhered foot plate may be employed. The external auxiliary ink supply (10) is preferably a bag (11) within a box. The system works by vacuum, and not by gravity, drawing the ink from the auxiliary reservoir (10) through the feed line (30) and into the cartridge (2) by vacuum developed within the cartridge (2). The feed line (30) need not be primed, thus avoiding ink leakage upon installation. Since the fill is via the vacuum check valve in the bottom of the cartridge, and the reservoir (10) can be at a negative head of as much as minus 4 inches, the system prevents back siphoning from the cartridge (2) and overflow from the external reservoir (10). Systems having multiple reservoirs for multiple color printers are disclosed. Once the delivery assembly (lay-flat bag or foot plate) is adhered to the bottom of the OEM cartridge (2), further reservoir replacement is via a twist connector (31) adjacent the reservoir (10). There is no ink leakage as the system is under negative pressure.



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Auxiliary Ink Reservoir and Feed System and Method For Ink Jet Cartridges

DESCRIPTION

CROSS-REFERENCE TO RELATED APPLICATIONS AND CLAIM OF PRIORITY:

This application is based on and claims priority from two U.S. Provisional Applications Serial No. 60/016,919, filed May 6, 1996 and Serial No. 60/025,211, filed August 23, 1996 by us, both entitled "AUXILIARY INK RESERVOIR AND FEED SYSTEM FOR INK JET CARTRIDGES". This application also applies to apparatus and methods of auxiliary feed of ink jet ink of the type disclosed in our copending application Serial No. 08/558,143, filed November 13, 1995, entitled "INK COMPOSITIONS HAVING IMPROVED OPTICAL DENSITY CHARACTERISTICS", the disclosure of which is hereby incorporated by reference.

TECHNICAL FIELD:

The invention relates to an ink refill system to continuously replenish both pigment and/or dye-based inks in cartridges of ink jet printers, plotters, copiers, and fax machines. A variety of embodiments are shown for black ink and multiple color ink systems, the principal embodiment of which is characterized by a bag reservoir, a feed tube with screw-on or clip-on reservoir connector, and a special lay-flat tube adaptor at the outlet end of the tubing for connection to the vacuum relief check valve port in the bottom of the main (original) cartridge of the ink jet printer for use-generated, self-regulated vacuum draw of ink from the reservoir into the cartridge.

BACKGROUND ART:

Ink jet printers, plotters, copiers, and fax machines, particularly those for home or business or legal office use, have original ink cartridges of limited volumetric capacity, typically on the order of 40-50 ml. This provides printing approximately 800-1000 pages of text at 5% coverage. The typical ink jet printers, plotters, copiers or ink jet plain paper fax machine, such as the Hewlett-Packard series units, do not have systems for indicating remaining ink status or low ink conditions to prevent running out of ink in the midst of a printing job. There are a number of proposals for auxiliary or reservoir feed systems which typically involve drilling a hole in the top of the original printer tank, and inserting a tube into the tank. These are generally gravity fed, and may cause problems with the pressure differential between atmosphere and the inside of the original ink cartridge which is ordinarily under a slight but controlled negative pressure.

For example, Crystal, et al. (Graphic Utilities) U.S. Patent 5,488,400 shows a top fill arrangement for refilling an ink cartridge. Ruder U.S. Patent 4,967,207 (Hewlett-Packard) shows a top fill (needle) system separate from a top mounted vacuum port. The cartridge is moved to a service station that involves a valve that connects to the top fill needle and another valve connects to the vacuum port. A vacuum is drawn in the cartridge and it is batch filled with colorant through the separate fill needle. Erickson 5,367,328, 5,369,429, and 5469,201 are three related patents directed to various aspects of a continuous top ink fill system which include an in line regulator for controlling the flow of ink. Cowger, et al. U.S. Patent 5,010,354 is directed to a primary ink reservoir connected to a

capillary volume element that is intermediate in pressure between the low pressure in the ink reservoir and external atmospheric pressure. As the ambient atmospheric pressure or temperature varies, the capillary element absorbs or discharges ink so that the primary reservoir pressure remains substantially constant so ink does not leak out the printhead orifices.

Such systems typically involve top feed, and either require special modifications of the printer cartridge by the consumer for retrofitting the auxiliary ink feed system, or a specially designed cartridge not of original equipment manufactured design to receive the external tank feed tube. A retrofit requirement is to drill a hole in the top of the tank, which can deposit debris in the tank. Such systems typically require skills and equipment that many consumers either do not have, or the systems require operations that consumers do not care to do.

Inks are complex compositions or mixtures. They are generally considered to be active, and must be maintained under controlled environmental conditions to maintain consistently high printing performance and print quality. By way of background in connection with certain types of problems of inks, including print rate, coverage, density and the like, see our copending application Serial Number 08/555,143 filed November 13, 1995, the disclosure of which is incorporated by reference herein to the extent need be for full and adequate disclosure of ink characteristics.

Modern ink jet printer cartridges operate under slight negative pressure, inter alia to prevent leakage of ink through the ink jet nozzles when the printer is not in use, and to assist in proper ink droplet formation during printing. There are a variety of devices incorporated in cartridge construction,

including a lung-type spring-biased bellows system, and an inlet check valve which permits introduction of small bubbles of air as the ink volume within the generally sealed tank is reduced through usage. As the ink is used, the volume of ink within the reservoir is gradually reduced, and an increasingly negative pressure is created within the tank. If the pressure drops too low, then the cartridge will exhibit stall failure, in that the negative pressure within the tank will prevent feeding ink through the print droplet-forming ports or jet apertures. Accordingly, the check valve permits bleed-in of small bubbles of air to help maintain the pressure, hence the name vacuum relief valve, or vacuum check valve or the more colloquial name of "bubble generator." In addition, the spring bellows expand slightly to compensate for loss of ink volume thus assisting in control of the pressure. The check valve and bellows within the cartridge are carefully balanced so that one can counteract the effect of the other to an extent such that the pressure curve flattens out and remains relatively constant as the volume of ink drops in the cartridge through usage.

Thus, any external ink replenishment system must not interfere with the overall balanced pressure characteristics of the original cartridge as each cartridge type is "tuned" to the particular printer speed, droplet size, ink characteristics such as viscosity, drying time, nature of ink (pigmented versus dye based inks), etc. Further, any external feed system must be very simple and foolproof to retrofit, not involve special tools, and not be messy. Where there is a long air-filled feeder line from an external reservoir to the original cartridge, depending on the volume in the line, the pressure balance in the original tank can be adversely affected if that air were bled-in to the

original tank in order to establish the ink feed from the auxiliary tank. That is, presently proposed external tank feed systems require priming the feed line from the external tank to the original tank. This can lead to spills, and poses a skill barrier to adoption by many consumers.

In addition, currently available external feed tank systems require a positive head in order to prevent backflow or siphoning out of the original tank to the auxiliary reservoir. Thus the auxiliary reservoirs need to be placed above the original tank, or they will require anti-siphon valves within the system. If the external tank is placed too high, the head may be too great and force too much fluid into the original tank. Likewise, if the tank is too low, pumping would be required or one could have a backflow siphoning effect potentially causing spillage of ink in the area of the external tank.

Accordingly, there is a need in the art for a simple external ink reservoir and feed system that avoids the problems of the art, is simple to retrofit, works well with the original cartridge system and does not upset the delicate pressure balance and integrity of the original cartridge and the printer to which it is tuned.

DISCLOSURE OF INVENTION:

It is among the objects and advantages of this invention to provide an improved external auxiliary ink reservoir system, particularly suited for ink jet printers, plotters, copiers, and fax machines for business and personal applications which avoids the problems of the prior art. A principal object and advantage of the invention is to feed the OEM ink cartridge through one of the OEM-provided openings of the cartridge (as defined below)

so that the auxiliary ink feed system of this invention becomes (and is an as-you-print-created vacuum draw system, and not a gravity head system. This makes the system an anti-back flow, anti-siphon system in which the combination of cartridge negative pressure and feed tube inner diameter are tuned to the particular printer speed preventing stall-out. The feed tube need not be primed, thus avoiding messy leaks or requiring added operator intervention upon installation. Once installed, the cartridge does not have to be removed from the machine. The apparatus of the invention preferably employs one or more check valves at any convenient place in the system, as described in more detail below.

The external ink feed system invention comprises an external ink tank or reservoir which is removably securable to any convenient location, such as an adjacent wall or cabinet, or to the top or a sidewall of the printer, plotter, copier, or fax unit, and which is preferably a bag in a box. The box can have an aperture or window in a side wall thereof so that the reservoir bag is visible. Indicia printed or adhered on the box side wall or on the bag itself provide a gauge for the quantity of ink remaining. A typical bag is volumetrically on the order of 84 milliliters, but may be any convenient size. The ink reservoir bag includes a connector which mates with a screw-on or elastomeric diaphragm puncture-type fitting on the proximal end of an ink feed tube (supply line) assembly. The ink feed tube is typically a 1/32" ID PVC (e.g., Tygon) tube which includes a flex shield, which is typically a plastic coil wrapping around the tube to provide both support and prevent kinking. The feed tube is led from the external tank to the ink cartridge of the printer, plotter, copier, or fax along any

convenient path. For example, the tube routing may be around the back of the printer, through the gap between the printer housing and its cover, thence across the inner housing to the cartridge. The tube may be taped or clipped to the top of the printer body housing with a loop to the right side to avoid interference with the printer control ribbon which loops to the left. In an HP Fax 900 or Ink Jet 600c the tube may be fed across the midsection of the device housing. In the HP 600 series printers the auxiliary reservoir is conveniently placed on the left side of the unit.

The distal end of the ink feed tube assembly terminates in a delivery device for providing ink flow to the vacuum relief valve in the bottom of the cartridge. In the preferred embodiment, a lay-flat tubing assembly, also called a foot bag, is adhered with double-sided tape to the back and bottom of the cartridge. This delivery tubing assembly typically has a thickness of .040" and is sufficiently thin to fit the tight clearances of currently conventional ink jet cartridges. The lay-flat tubing wraps around the lower front corner of the cartridge assembly. The inner face of the lay-flat tubing has an aperture which is coordinate with the vacuum relief valve opening. Internal ribs running longitudinally the length of the lay-flat delivery tubing assembly prevent it from collapsing or pinching sheet where it is bent around a corner of the cartridge. Alternatively, a bag spreader assembly may be employed.

Alternative embodiments of the distal ink feed system to the vacuum relief valve include a foot plate which is fed directly by the ink delivery tube or plug/feed tube assembly (for spring-bag-type cartridges). The foot plate is adhered to the bottom

of the cartridge. A channel from the tube to an opening aligned with the vacuum relief valve is provided.

The auxiliary ink system of this invention may be employed for printers, plotters, copiers, and faxes using multiple color ink cartridges by having multiple external reservoirs mounted on the printer or on a wall or horizontal surface adjacent to the machine. A multiple lumen feed tube may be used, with each lumen dedicated to a particular reservoir color and terminating in lay-flat tubing feed assembly or foot plate at the appropriate cartridge. Thus, for color printing, four external reservoirs can be provided, black, cyan, magenta and yellow. For hexachrome printing, two additional reservoirs for green and orange may be provided. Special auxiliary ink reservoir systems of the invention can also be used for "spot color" applications.

Once the lay-flat tubing or foot plate is applied to the cartridge, refilling occurs externally without removal of the cartridge from the printers. A twist-type or clip-type connector is provided on the proximal end of the ink feed tubing. The connectors preferably employ a rigid, blunt, tapered, cannula (tubing) that is pushed through a soft elastomeric disc-type sealing plug in a connector tube sealed in the reservoir bag wall. As the external reservoirs become empty, they may be removed from the Velcro® hold fast on the side of the printer (or wherever placed) and replaced with a fresh reservoir. The combination of the small lumen in the ink feed tube, the ink viscosity, the negative pressure of the system and optional cartridge check or pinch valve(s) prevent ink dripping out of the feed tube when switching bag reservoirs. As the system does not depend on gravity feed, the reservoir bag can be placed in any convenient position. The bag itself, or the ink level within the

auxiliary reservoir of this invention can be as low as about a minus 4" head for a 1/32" ID feed tube. That is, the ink level can drop 4" without stalling, which permits vertical or horizontal orientation of the bag.

The feed tube can be a single lumen, or it could be multiple continuous tubules or capillaries for single or multi-color ink reservoirs. Likewise, the ink can flow over the surface of filaments via surface capillary conduction. Priming is not necessary as the air in the line goes first into the ink cartridge as the printing creates the necessary drawing vacuum in the cartridge. The entire quantity of air in the feed line from the reservoir through the lay-flat tubing is on the order of 1 to 4 milliliters. Thus, the ink level would drop approximately 5-10% in the cartridge whereupon the replenishment ink feed starts from the reservoir.

The reservoir bag and lay-flat tubing are preferably of ethyl vinyl acetate (EVA) plastic of sufficient thickness to provide a barrier layer, or may be a multiple layer plastic bag and tubing. It is preferred to have a barrier layer to prevent deterioration of the ink through gases (O_2 and CO_2) exchanged through the plastic bag and to prevent evaporative loss of solvent liquid (e.g., water) through the bag walls. Likewise, the reservoir bag, ink feed line and lay-flat tubing need to be of sufficiently high quality plastic to prevent on-shelf or in-use aging and cracking causing leaks. The reservoir bag in the box preferably has internal ribs and/or a tip tube, and they may be oriented vertically. The connector between the reservoir bag and the feed tube may be placed at the bottom of the bag, or a bottom corner of the bag, but this is not absolutely required as the ink is fed by vacuum. The bag

gradually collapses and the ink can feed upwardly in the bag by capillary draw resulting from surface tension and ink viscosity. Indeed, having the bag outlet adjacent the top is an additional safety feature in that it resists siphoning or leakage. Typically, the box in which the reservoir bag is supplied is factory sealed, so that the consumer when installing the system handles the box and not the bag. The box provides an additional safety barrier from the bag becoming accidentally pierced by scissors, pencil points, and the like, which are frequently used around the office.

In the foot plate embodiment, the foot plates are conveniently made of two layers of ABS plastic, each on the order of 1/16 inch thick which are glued together, but is preferably a single 1/8 inch thick layer. The Tygon ink feed tubing is typically solvent glued to the plastic fittings. The anti-kink coil is typically a polyolefin plastic. The ink feed tube is typically on the order of 24 inches long but may be any suitable length.

As an alternative present best mode embodiment for springbag-type cartridges, the invention comprises inserting a plug/feed tubE assembly having an in-line check valve through an aperture in the perimeter wall of the cartridge. Such cartridges include the HP 51640 series (51640 A, black; 51640 C, cyan; 51640 Y, yellow; 51640 M, magenta; the corresponding 51650 C,Y,M series for plotters; 51645A, black for printers and plotters; and the 51644 C,Y,M series for plotters). The aperture may be a special hole drilled in the perimeter wall (e.g., by an after market refill house), or may be derived by removal of an OEM fill plug, which is typically a ball press-fit in the hole in the perimeter wall to seal the fill hole. The ball can be pushed into the cartridge to reopen the OEM file hole.

In one alternative for this springbag cartridge auxiliary fill system, an annular plug is provided to seal the aperture (drilled hole or OEM fill port). The annular plug has a center bore through which an ink feed tube passes from the auxiliary reservoir. An inlet check value is employed at any convenient place in the line, or may be provided as part of the annular plug assembly. In the present best mode for this auxiliary fill system for springbag cartridges, after the ball plug is pushed into the cartridge, a foot plate or foot bag is placed over the hole. The foot plate or foot bag can include a rigid tubular ball pusher that has a center bore connected to the channel in the foot plate or to the aperture in the bag. The ball pusher is centered on the OEM ball plug. As the foot plate is pressed into the cartridge the ball is pushed into the cartridge and the foot plate (or foot bag) is sealed to the cartridge at the same time. This sealing can be accomplished in a number of ways: via tape on the cartridge-facing side of the foot plate, by snap-in of the ball pusher in the ball plug hole, or by other friction or interference fit of resilient material in the ball plug hole.

Where check valves are used in the system of the invention, they act as a safety as compared to prior art ink resupply systems that are open to the atmosphere. In such "open" systems, if the auxiliary reservoir is disconnected or runs out of ink, air can be introduced through the line (luer) into the cartridge and ink leaks out the head; the bladder system becomes non-functional due to pressure imbalance.

In the conventional sponge type cartridge, there is a small open-to-atmosphere port, which may be a plug having a calibrated borehole. The system of this invention involves providing a lumen to insert in the borehole or in the hole remaining when the

port plug is pushed into or extracted from the cartridge, or a foot plate or foot bag placed over the port or borehole. The lumen can be pushed partway into the cartridge or all the way through the sponge to the bottom of the cartridge, providing either top fill or bottom fill. In all three embodiments, the port is sealed, either with an annular plug or via the sealing surface of the foot plate or footbag, and an inlet check valve is employed in line, or with the port seal mechanism, or in the foot plate or bag or in association with the auxiliary reservoir. The sponge cartridge now is converted to and operates as an negative pressure cartridge. The pressure dynamics of a sponge cartridge system will ordinarily require a somewhat lower spring force in the check valve, i.e. the check valve opens at a lower negative pressure, to counterbalance the sponge plus negative pressure in the cartridge, to permit ink feed from the auxiliary cartridge and prevent cartridge stall.

The invention, being a pull-through system based on vacuum created by printing demand, is ideally suited to future cartridges where the OEM fill port and ball plug system is eliminated. That is, OEM manufacturers in the future may decide to do the fill through the bubble generator by first evacuating the cartridge ink space, thus eliminating the need for an OEM fill port. The system of this invention is ideally suited to this initial fill strategy where an initial vacuum is created in the cartridge and a sealing member is placed surrounding the bubble generator port, which in turn is connected via a tube to an ink supply. The sealing member (such as an O-ring or other resilient annular structure) is retracted from the cartridge once filled, and applied to the next cartridge in line. Either a vacuum can be pulled on the cartridge via the bubble generator,

as the internal spring bladders ("lungs") can be inflated by pressure through the open-to-atmosphere pressure equalization port. Pressurizing the lungs forces air out the bubble generator. Once the sealing ink feed assembly is placed over the bubble generator, the lung pressure is released and the collapse of the lungs draws ink into the cartridge, filling it.

Of course, the cartridge does not know whether this is an initial fill or a refill. Thus, the process aspects of this invention include thee methods for both initial fill and refill. For a refill, a kit can be provided with a small rubber bulb pump and a foot plate, or other ink feed sealing member, that is sealingly connectible to the bubble generator. The bulb tip is inserted in the air port of the lungs on the top of the cartridge and the compressed, forcing air out the bubble generator. The cartridge is preferably inverted during this procedure to prevent residual ink leakage. Once compressed, a sealing member (connected to the ink supply) is placed over the bubble generator, the bulb is released and the ink is drawn into the cartridge. The proximal end of the ink feed tube can then be connected to another full auxiliary ink reservoir to continuously replenish ink as described above. A unitary "fill station" assembly may be provided, where the empty cartridge is inserted in a holder that has a mating bulb/pump inlet and a sealable ink inlet. This can be used in production for initial fill, in which case it is automated, or in a kit form for individuals to use aftermarket.

In another embodiment of the invention, a fill kit can be provided having a tubular piercing device that passes through the hole in the top air port (e.g. of an HP 51626-type cartridge). The tube is long enough to pierce the thin metal foil disc-type

septum. Ink may be gravity or pump fed through the tube. The tube is either multi-lumen, with at least one being an air outlet, or may have side grooves to permit air to exhaust from the cartridge during the filling process. In the alternative, the cartridge can be inverted, and air escapes out the bubble generator. Or a vacuum can be drawn first or simultaneously through the bubble generator, in which case the tubular piercing device is single lumen and sized to fit the full diameter of the air port.

This multi-lumen air port fill approach is also useful for the springbag-type cartridges, in which case the broad flexible sides of the cartridge can be squeezed to exhaust air from the ink reservoir zone of the cartridge.

BRIEF DESCRIPTION OF DRAWINGS:

The invention is illustrated in the drawings in which:

Figure 1 is an isometric view from the right side of a typical printer or plotter showing the preferred mounting location of the external ink reservoir and the ink feed tube path to the lay-flat tubing delivery assembly for feeding into the bottom of the cartridge;

Figure 2 is a front 3/4 elevation showing the distal end of the feed tube of the external ink feed system of the invention terminating in the lay-flat tubing delivery assembly wrapping around the front and bottom of the cartridge;

Figure 3 is an exploded isometric view of the preferred, best mode of the reservoir bag and the protective mounting box;

Figure 4 is an exploded isometric of the ink reservoir bag fitting and the twist-on fitting at the proximal end of the ink feed tube;

Figure 5 is a side elevation view of a portion of the presently preferred ink reservoir bag and ink tube connector assembly;

Figure 6 is an exploded isometric view of the lay-flat tubing assembly and the double-sided tape which secures it to the back and bottom of the cartridge;

Figure 7 is an isometric view of the lay-flat tubing assembly as secured to the cartridge;

Figure 8 is a section view taken along lines 8-8 of **Figure 7** through the cartridge and lay-flat tubing assembly showing it adhered in place;

Figure 9 is an enlarged, partly broken away, section view of the back and bottom of the cartridge showing the detail of the securement of the delivery tubing assembly to the cartridge;

Figure 10 is an isometric view of an alternative embodiment of the lay-flat tubing assembly showing a bag spreader internal to the tubing;

Figure 11 is an isometric view showing one embodiment of the foot plate assembly mounted to the cartridge;

Figure 12 is an exploded isometric of the foot plate assembly embodiment shown in **Figure 11**;

Figure 13 is a section view of the foot plate assembly of **Figure 12** taken along lines 13-13 in **Figure 12**;

Figure 14 is an exploded isometric of a second embodiment of the foot plate assembly showing how it is mounted to the bottom of the cartridge and illustrating the vacuum relief valve location;

Figure 15 is an isometric view of a sponge filled ink reservoir bag;

Figure 16 is an isometric of the system adapted to multiple color printing showing a plurality of external reservoirs and multiple feed tubes to multiple color cartridges; and

Figure 17 is a section view through the foot plate of **Figure 11** along lines 17-17 in **Figure 12**;

Figure 18 is partially schematic, partially broken away, isometric view of a conventional springbag-type cartridge showing two alternative placements of the distal connector and feed tube;

Figure 19 is a section view through the ball pusher foot plate assembly of taken along line 18-18 of Figure 17.

Figure 20 is a schematic, view of an initial fill/refill system particularly suitable for refill kits, employing air pressure through the air port and ink fill through the bubble generator for cartridges having spring bladders and not having a fill port or in which the fill port plug is not removed or removable;

Figure 21 is a schematic, partial section view showing an initial fill system for cartridges of the type of Figure 20 in which a valve is used to switch between a vacuum source and an ink reservoir for initial fill or refill through the bubble generator;

Figure 22 is a schematic section view of an alternative piercing fill needle system for refill through an air port which disables a spring bladder system of the cartridge; and

Figures 23A and 23B are section views of to two alternative needle configurations for the system of Figure 22.

DETAILED DESCRIPTION OF THE BEST MODES FOR CARRYING OUT THE INVENTIONS:

The following detailed description illustrates the invention by way of example, not by way of limitation of the principles of

the invention. This description will clearly enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what we presently believe is the best mode of carrying out the invention.

Figure 1 shows an isometric view of the external ink feed system 1 of this invention which comprises an external ink tank or reservoir assembly 10 and a feed tube assembly 40 which extends between the external ink tank assembly 10 and the standard cartridge 2 of the ink jet printer, plotter, copier, or fax machine 3. As described in more detail below, the feed tube assembly 40 has special connectors at the proximal, in-feed end to connect the tube to the external ink reservoir and at the distal delivery end to deliver the ink to the OEM ink cartridge. **Figure 1** illustrates the system of the invention viewed from the right hand side of the printer and particularly shows the arrangement from the external ink tank or reservoir assembly viewpoint, whereas **Figure 2** illustrates the delivery end of the connection of the feed tube assembly 40 to the cartridge 2 (discussed in more detail below).

Turning now to **Figures 3 and 4**, the external ink tank or reservoir assembly 10 comprises a bag-type reservoir 11 which is inserted in a box 12 which is secured to the side of the ink jet printer, plotter, copier, or plain paper ink jet fax as shown in **Figure 1** by double-sided tape or Velcro® hook and loop fastener system 13. As shown in **Figure 3**, the left end panel 14 is openable, and the bag reservoir 11 can be inserted and the end panel closed by the closure flap 15. The reservoir connector fitting 20 projects out the hole 16 at the right end of the box. **Figure 3** also shows an aperture or window 17 in the side wall for

viewing the bag volume level. Convenient volume indicator indicia 18 may be printed on the box. The bag 11 is typically a plastic bag which is compatible to the ink so that ink stability can be maintained. A good bag material is Mylar, PVC, PETE, polyolefin or an ethyl vinyl acetate-type polymer. The polymer type is not particularly critical, so long as it does not affect the characteristics of the ink, and it preferably includes a barrier layer to reduce or eliminate degradation by O_2 or CO_2 diffusing through the bag walls. The sides of the bag can be sealed adjacent the marginal edges as shown at 21A-D in **Figure** 3. The sealing also captures the interior end of the reservoir fitting 20 with a leak proof seal. The reservoir is shown mounted on the vertical right side of the printer, but it can be wall mounted as shown in **Figure** 16, or even mounted on a horizontal or inclined surface. Typical volume is 84 ml, but it may be any convenient size.

As shown in **Figure** 4, a suitable and exemplary type of fitting comprises an axial inlet 22, a spaced, coaxially larger cylindrical body 23 to which the bag is sealed, a shoulder 24, an external male connector tubing 25 having flanges 26 at the distal end thereof, and an internal ring-biased valve stem 27. The ink feed tube assembly 40 includes an ink feed tube 30 having a twist-on connector 31 at the proximal end thereof. The connector 31 includes a cylindrical body 32 with internal threads 33 which engage the tabs or lug 26 on the bag connector. Inlet tube 34 has an axial length sufficient to engage the valve stem 27 so that when the threads 33 engage the tabs 26 and the two pieces of the connector are tightened by rotating body 32, the valve 27 is opened by axial movement and the ink can be withdrawn from the cartridge. The ink feed tube may also be threaded

through an protective coil wrap or flex shield 35 that functions as a support and anti-kinking wrap. The tubing is preferably Tygon having an external diameter of 0.093" and a central lumen of 0.0313" internal diameter. A convenient length is on the order of 20-30 inches.

As best shown in **Figures 1 and 2**, the ink feed tube assembly 40 is led around behind the printer 3 up through the gap between the top lid 4 and the rear of the printer track housing 5 where it is secured by a hold-down tape or clip assembly 50. Other intermediate hold-down clips (not shown) may be used to secure the tube to any convenient surface. The feed type can be teed to feed more than one printer, especially where the reservoir 10 is large. An important feature of the tape hold-down is that it directs the ink feed tube assembly 40 at a diagonal from left to right across the top of the printer housing 5. This is best shown on **Figure 2** by the angle θ, which typically ranges from 30-60°. This angular securement causes the ink feed tube assembly 40 to snake to the right as shown by arrow 55 in **Figures 1 and 2**, as compared to the printer cartridge control ribbon 6 which snakes to the left between the printer 3 and the cartridge 2. This prevents the ink feed tube assembly 40 from becoming snagged on the cartridge control ribbon 6 as the cartridge 2 oscillates back and forth, left to right, during printing operations as shown by arrow A in **Figure 2**. Optionally, an anti-kink and support plastic coil 35 may be employed over the tubing 30 to prevent cut-off of ink flow due to kinking. Optionally, a pinch valve 45 may be employed to close the line when changing the reservoirs to ensure no leakage out the proximal end of the line, or from sucking air into the line if the printer is still running during reservoir change-out.

Figure 5 shows the preferred bag fitting 20 and female connector 31 at the proximate end of the ink feed tube 30. The end of the connector body 20 contains a self-sealing elastomeric disc-type plastic plug material 28 having a slit 29. The proximal end of the ink feed tube assembly tubing 30 fits into a cylindrical body 32 having a pair of opposed T-shaped spring clamps 36 A and B which are cantilevered at their centers by transverse web 37 and terminate in prongs 38 A and B. The prongs clamp over cylindrical end cap into which is press fit the elastomeric disc 28. The aperture cap 41 has an enlarged end or shank 25. By pressing the clamp ends 36A, B together, the prongs 38A, B are opened and the inlet tube 34, which is tapered at its end 39, is pushed into and through the slit 29 in the soft plastic plug material 28. The plug material seals against the side walls of the inlet tube 34 and the ink feed connection is accomplished. It permits use of a blunt tip 39 on the male connector 31 rather than a sharp metal hollow needle. the tip tube 52 in the bag 11 is inserted in the internal end 23 of the main body. The lumen 42 connects the lumen of tube 30 with that of dip tube 52. The bag 11 has interval, anti-wetting ribs 63 to prevent ink trapping as the bag empties.

The fittings described herein are typically a polyurethane isoplastic, such as made by DOW Chemical Company and the Tygon tubing 30 may be glued thereunto by cyclohexanone solvent bonding. The reservoir bag 11 is preferably HF/RF sealed EVA with a barrier layer. The plastic or cardboard box 12 is typically on the order of 3-3/4 inches high by 4-3/4 inches long. The best mode adhesive strip 68 is a closed-cell foam double-sided adhesive tape such as Scotch Brand VHB4932 25 mil. acrylic foam tape.

The bag 11 may be mounted as shown in **Figure** 3 which is self-collapsing as the ink is drawn therefrom by vacuum developed in the cartridge 2. Preferably, however, a dip tube 52 (shown in **Figures 2 and** 5) leads from the interior end 22 of the fitting 20 (see **Figure** 4) to the bottom of the bag 11. Alternately, the fitting 20 may be placed adjacent the bottom corner of the bag 11 rather than near the top.

Where priming is desired, the priming may be done by an inline squeeze ball primer, a check valve or port primer, by syringe introduction through a tee in the feed tube, or simply by finger pressure on the window 17 in the box 12. Air (or an inert gas) may be left in, supplied upon initial filling, or let into the bag during use via a check valve to improve ink level visibility. A universal screw-in filling, e.g., a luer-type fitting, may be used as the bag fitting 20.

The preferred embodiment of the ink delivery system to the cartridge 2 is a lay-flat "tubing" assembly 60. This is shown in **Figures 2 and 6-10**. As shown in **Figure** 6, the ink feed tube 30 is sealed to a lay-flat tubing 61 which conveniently may be a tube made from ethylene vinyl acetate, for example, made by Solmed and offered as its Medipak brand multi-layer polymeric lay-flat film (part number Solmed 9002). The tubing 30 is preferably directly sealed into the upper end 62A of the lay-flat tubing assembly, and the other end is also sealed shut at 62B. The tubing preferably has internal ribs 63 (63A, B) projecting inwardly from each inner tubing wall 64A, 64B. As best seen in **Figures 6 through** 9, these ribs prevent the lay-flat tubing from collapsing and pinching shut as the tubing is directed around the corner 71 formed by the juncture of the back wall 7 and bottom 8 of the cartridge 2. As best seen in the broken away portion

of **Figure 6**, the ribs 63A, B on opposite sides of the bag are offset so that continuous ink flow channels are maintained from the inlet tubing 30 to the delivery hole 65. While **Figure 6** shows a tapered wing type fitting 66, the direct sealing of the Tygon tubing to the EVA plastic of the lay-flat tubing 61 as shown in **Figures 7, 8 and 9** is the preferred embodiment. The ribs 63 maintain a full flow of ink. The bag ends 62A, B can be sealed, preferably by high frequency RF, which is conventional in the industry.

The inner face of the lay-flat tubing 61 is secured to the back 7 and bottom 8 of the cartridge 2 as shown in **Figures 7, 8 and 9** by means of a relatively heavy duty double-sided tape 68 which has a thickness sufficient to accommodate for variations in the molding in the bottom 8 of the cartridge 2 or the upper flange 19 of the cartridge. The currently preferred double-sided tape 68 is a double-sided gasket material, 3M Scotch Brand VHB (very high bond) of .025 inch thickness, having high bonding adhesive on both sides.

As shown in **Figure 6**, a hole 69, which is coordinate with the aperture 65 in one wall of the lay-flat tubing foot bag 61, is provided in the tape 68. The first protective peel-off tape (not show in **Figure 6**) is removed from the tape 68 and it is adhered to the inner face of lay-flat tubing 61 with the holes aligned. Later, at the time of application, the customer peels off the other protective facing tape 70 and adheres the lay-flat tubing assembly 61 to the bottom and back of the cartridge as shown in **Figures 7, 8 and 9**. As best shown in **Figure 9**, the hole 65 in the inner face of the tubing 61 aligns with the hole 69 in the double-sided VHB tape 68. In turn, both of these align with the vacuum relief valve aperture 9 in the bottom 8 of the

cartridge 2. As best seen in **Figure 9**, the staggered ribs 63A, 63B maintain spacing around the corner 71 to permit continuous ink flow. The total thickness of the lay-flat tubing is on the order of .040" ± .010" inch even when permitting ink flow therethrough, thus providing ample clearance even in the Hewlett-Packard:900 series plain paper fax machines. In the Hewlett-Packard:500 and 600 series Desk Jet printers, there is even more clearance.

Figure 10 shows an alternative method of insuring that the foot bag is maintained open by means of a bag spreader 75 which comprises an inlet connector 76 terminating in a flange 77 to which the bag is sealed. Projecting from the flange are a pair of long flexible plastic or metal fingers 78A, B. The fingers are thin and highly flexible, and while bendable, prevent the foot bag from collapsing so that the aperture 65 in the one wall can be aligned with the vacuum check valve 9 as described in connection with **Figure 9**. The connector fitting 76 receives the tubing 30.

Figures 11 through 14 and 17 show several embodiments of additional embodiments of the distal ink delivery system of the ink feed tube assembly 40. These embodiments are generally termed "foot plate" embodiments.

With respect to **Figures 11 through 13 and 17**, the supply line (tube 30 wrapped with anti-kink coil 35) is led across the top corner of the cartridge 2 and is held in place by clip 81. The bare tubing 30 is then led down the back 7 of the cartridge to a male connector 82 which is inset in a hole in the upper plate 85 of a foot plate assembly 80, which may be a single layer as in **Figures 11 and 17** or two layers as seen in **Figures 12 and 13**. As best seen in **Figures 12 and 13**, the connector 82 leads to a

channel 86 in the lower layer 87 of the foot plate 80. This channel is led diagonally to a hole 88 in the upper layer 85. The foot plate hole 85 sealingly mates with the vacuum relief valve 9 in the bottom 8 of the cartridge 2 as best seen in **Figure 11**. An o-ring 89 may be used to assist in the seal. As noted, **Figure 13** is a section view taken along the line 13-13 of **Figure 12**. Note also that the foot plate forward end 91 has one or more notches 92 or ears 93A, B which mate with the corresponding relieved portions 94A, B in the foot of the cartridge as best seen in **Figures 7, 8, 11 and 14**. The ink is fed down the tube 30, through the connector 82, thence through the transverse diagonal channel 86, and is sucked up through the opening 88 via valve 9 as the ink pressure drops inside the cartridge 2.

Figures 11 and 17 show the best mode of the single layer embodiment of the foot plate, in which channel 86 is a bare formed by cross-drilling from an edge through entry 90. The tubular connector 82 is inserted in hole 83 and the tube 86 terminates in hole 88. The inner end of the tube 82 includes a relieved portion 84 on one side which permits ink flow into tube 86. The entry 90 is then filled with an appropriate glue plug 96, also shown in **Figure 11**.

Figure 14 shows an alternative foot plate 80A in which the tube 30 is fed into a corner 95 of the foot plate through channel 86 and thence through a hole 88 which mates with the vacuum check valve 9 in the bottom of the cartridge 8. In this instance, the double-sided tape surface 68 is shown. As noted by arrow B, the foot plate is turned over 180° to mount the foot plate on the bottom of the cartridge so that the tubing 30 is led up along the corner 97 of the cartridge 2.

Figure 15 shows an alternative embodiment in which the reservoir bag 11A is filled with a sponge, open celled plastic foam, beads, microtubes, or other ink retaining material 98, which retains and supplies ink by capillarity. A check valve 43 may be provided in line and an inlet, vacuum relief check valve 44 is advantageously mounted to the bag to prevent backflow and printer stall. As shown, the end entry is used in a Hewlett-Packard printer while a side entry (not shown) can be used for a Canon printer.

Figure 16 shows a multiple feed system for printers, plotters, copier, and faxes which use various colored inks. Note the external reservoir system 11C comprises a plurality of reservoirs, identified K for black ink, C for cyan (blue), M for magenta and Y for yellow. These are fed through multi-lumen ink feed tube assembly 40 which is secured by clip 50 with each of the tubes terminating in a lay-flat bag assembly 60 (not shown) for their respective cartridges (also not shown in **Figure 16**). While the bag 11 of the external reservoir 10 shown in **Figure 3** typically has a volume on the order of 84 milliliters, which is double the OEM cartridge capacity, the system shown in **Figure 15** may use much larger, wall-mounted reservoirs, which themselves can be refilled through appropriate closures 99. A single reservoir may be manifolded to multiple cartridges in separate printers, plotters, copiers, or faxes, or to multiple cartridges in the same device, e.g., a plotter with multiple same or different color pens.

Figures 18 and 19 show the invention adapted to a standard springbag-type cartridge 100 having a perimeter wall 102 in which is located an OEM fill port aperture 106 which is sealed after the initial filling by a steel or plastic ball plug 104. The

application of the invention to these types of cartridges is by use of a sealing member 108, typically a foot plate or footbag, which includes rigid tubular ball pusher 110. As best seen in **Figure 19**, the ball pusher is placed against the port 106 and pushed inwardly to remove the ball 104 which falls to one side in the cartridge as seen in **Figure 18**. Continuing to push seals the foot plate to the cartridge wall by means of double sided tape 109. The ball pusher includes a center bore which is connected to the ink channel 112, which in turn is connected to an ink feed tube 114. Conveniently, a check valve 116, which typically comprises a ball 118 and spring 120, may be provided at any convenient place in line.

The upper right corner of Figure 18 also shows an aftermarket solution not involving a ball pusher. In this embodiment, a hole 122 is drilled in the perimeter wall 102 and a plug 126 is sealingly seated in the hole. Conveniently, the plug can terminate in a delivery tube or diptube 124 which is connected to the ink feed line 114. If desired the plug can include a check valve 116 of a ball and spring type 118, 120.

Figures 20 and 21 show two alternatives for initial OEM fill and subsequent aftermarket refilling of standard cartridges of the HP 51626, -29, -33M and Encad types, series where such cartridges do not have a ball-plug fill hole on the top or it is determined that removal of the ball plug is not feasible or not desirable. In **Figure 20**, a fill station 130 is provided which comprises a cartridge holder 132 mounted to support 133 (shown schematically) which grips the cartridge 134 in an inverted position. An air pressure assembly 136 is provided having an inlet line and a sealing member 138 for sealingly engaging the air vent or air port 140 at the inverted top of the cartridge.

In addition, an ink supply assembly 142 having a sealing member 144 is provided for sealingly engaging the bubble generator 146. A flexible line is connected to an ink supply 148 which conveniently may have a check valve 150. In this embodiment, the air pressure and ink supply assemblies 136, 142 are linked by an actuating mechanism 152, shown schematically. The solid dots are pivot points. The lever 154 is connect via links 156A and 156B to the air pressure supply and the ink supply, respectively.

In operation, the cartridge is placed in holder 132 of fill station 130. The lever 154 is pressed down as shown by arrow A. This contacts the air pressure supply 136 to the air port 140, while simultaneously raising the ink supply sealing member 144 away from the bubble generator 146. Air pressure is supplied through the air port 140 and the internal Spring bladders or lungs 158 expand from position 158A to 158B forcing air to escape from the remaining volume inside the cartridge via the bubble generator 146 or the jets 147. The volume on the interior of the cartridge 160 which holds the ink is thus reduced. In the second step of the operation, the lever 154 is raised as shown by arrow B. This causes the ink supply sealing member 154 to sealingly engage around the bubble generator port 156 while unsealing the air port 140 as the sealing member 148 is removed from engagement with the inverted top of the cartridge. The air pressure from source 136 is stopped, but the pressure is maintained to keep the lungs in the inflated position before the lever 154 is actuated to the raised position. In addition, a lost motion link in the linkage 152 (not shown) causes the seating of ink supply sealing member 144 before the air pressure sealing member 148 is removed from the air port. Alternatively, pressure can be introduced or removed by a valve rather than by

the physical actuation of the seal 138 to or from the surface.

Once the ink supply connection is made, the air exhausts from the lungs 158 creating a vacuum in the cartridge ink volume 160 and ink is drawn from the ink supply 148 to fill the cartridge. The cartridge is then righted and reinstalled in the printer, plotter, copier or fax and used in a conventional manner.

Figure 21 shows an alternative system for filling a cartridge 134. While this is principally suitable for initial filling by an OEM, as it requires a vacuum source, enough vacuum can be provided by a manual pump such that it can be part of an aftermarket kit or refill station.

The cartridge 134 is clamped between a base 172 and hold downs 174A and 174B. The base, hold downs and supply system 176 are shown in schematic. A seal member 182 is recipricatingly sealable against the bottom of the cartridge around the bubble generator 146 as shown by arrow R. A three-way valve 178 is turned so that it connects to a vacuum source 180. A vacuum is drawn in the ink supply space 160 of the cartridge 134 and the spring bladders 158 swell from the collapsed stage 158A to the enlarged state 158B by draw in of air through the air port 140. Then the three-way valve 178 is rotated clockwise as shown by the arrow 184 to connect ink supply 148 to the interior of the cartridge 160. The ink is drawn into the cartridge as the bladder 158 collapses and air is exhausted out the air port 140. The valve is closed and the seal member 182 is removed from the bottom of the cartridge. The cartridge is removed from the hold downs and another cartridge is automatically shuttled in place for filling.

Figures 22 , 23A and 23B shown in partial section view still another embodiment of the invention by which a cartridge 134 is filled through the air port 140. The air port is a passage way in plug 196 which is seated in an OEM aperture 198 in the top of the cartridge. The plug 196 is generally T-shaped and has lateral flanges 214 to which the bladder assembly 190 is secured. The bladder assembly includes a pair of bags 194A and 194B and flexible spring metal wings 192A and 192B. There is also a circular thin metal foil diaphragm 204 which seals the assembly so that there is a continuous air passage 202 from the air port 140 into the bags 194A and B. An ink supply needle 206 is pushed downwardly through air port 140 so that its tip pierces the foil diaphragm 204. The needle has a central lumen 208 which connects to the ink supply 148. By rupturing the diaphragm, the spring bladder assembly 190 is disabled. The filling of the ink through the luer 208 ensures that the bladders 194A and B remain collapsed. Air escapes through the rupture in the diaphragm 204 and then out a gap or notch 210 between the needle and the wall of the port 140. This is best shown in **Figure 23**. Once the cartridge is refilled, a plug or seal member (e.g., cylindrical plug with a disc shaped top) is used to seal the air port 140.

Figures 23A and 23B show two alternative embodiments of the fill needle 206 having a center bore or lumen 208. In **Figure 23A**, the needle 206 is oval thus leaving a gap 210 between the side wall of the needle and the inner wall of the air port 140. In **Figure 23B**, the needle may have one or more axially parallel grooves 212 which leaves a space 210 between the needle side wall and the port 140.

INDUSTRIAL APPLICABILITY:

In actual tests, a prototype of the external feed reservoir system of this invention having an 84 milliliter double cartridge capacity successfully printed approximately 2400 pages continuously at 5% coverage with no cartridge interruption. That is, the original cartridge capacity on the order of 800 pages was tripled by attachment of the external feed system of this invention. The inks employed were those shown in our copending application serial number 08/558,143, filed November 13, 1995. The printer employed was an Hewlett-Packard Desk Jet 560C employing black ink. The ink density was entirely satisfactory.

It should be noted that the system of this invention employs a vacuum draw created by the printing. Thus, this as-print-created vacuum draw ink feed system has a distinct commercial advantage with great industrial applicability since the external reservoir of this invention is less sensitive to height placement than those of the prior art in which a positive feed head was essentially critical to their operation. In contrast, in this invention fluid head is of little or no importance. Thus, the system is far more applicable and useful by unskilled people who have no appreciation of fluid dynamics and either have no wish or no inclination to learn about such problems. Thus, the instant invention solves a serious prior art problem of reservoir placement. Further, it easily triples ink capacity, extends the life of the ink cartridges, saves money on replacement cartridges, is fast and simple to use, clean to install, allows ink level viewing, automatically shuts off, and requires less frequent changing of ink supplies.

Further, since the system of this invention is a vacuum draw system, the feed line 30 from the reservoir 10 to the cartridge 2 need not be primed. That is, the lay-flat tubing assembly 60

or foot plate 80 is merely secured to the bottom or/and back of the cartridge with the hole aligned with the vacuum relief valve 9. Since there is no ink in the feed tube and none in either the foot plate or the lay-flat tubing assembly, when the protective tape 70 is peeled off, there is no messy leakage or poor seal. In addition, the system is under negative pressure, the ink is of sufficient viscosity and the lumen of the tubing 30 is sufficiently small that ink does not dribble from the tube 30 when changing reservoirs. Note that once the first installation of the lay-flat delivery assembly 60 or foot plate is made, subsequent reservoir replenishment is made via twist connector 20. No ink dribbles from the tubing 30 for the same reasons. The application is simple, clean and essentially fool-proof.

The auxiliary ink system of this application will find wide applicability to a wide variety of printers, plotters, copiers, and plain paper faxes employing ink jet technology. Examples of these include: Hewlett-Packard:900 series plain paper faxes, Desk Jet and Desk Jet Plus printers of the 500, 600, 1200C and 1600C series; Desk Writer and Desk Writer C series; plotters of the 650C and 750C series; and the ENCAD, Novajet I, II and III series. Examples of single reservoir to multiple cartridge systems are the Hewlett-Packard Design Jet or Bryce envelope addressing printer. Without limitation, the system of this invention is applicable to the Hewlett-Packard cartridges of the following systems, 51625A; 51626A; 51640C, Y, M; 51640A (Black); 51649A; 51650C, Y, M; 51633M; 51645A and the Hewlett-Packard: -26A and -29A series cartridges. The auxiliary ink feed system of this invention may be easily adapted to cartridges, printers, plotters, copiers, and fax machines of other manufacturers, and for both pigment-type and dye-based inks. HP 51625A and 54640,

51649, 51650 series cartridges have no bubble generators. Thus, we can use the alternative embodiments of the invention as described above for the springbag-type cartridges.

In a particularly useful example of applicability of the invention, a single large auxiliary reservoir can be plumbed with multiple lumens (feed lines) to feed multiple cartridges in a single machine, e.g., a Pitney Bowes addressing machine in which individual cartridges are dedicated to specific address lines, or to an HP "Design Jet 200" or "Design Jet 600" which currently employ two cartridges. The multiple feed lines can be direct from the large reservoir, or may be manifolded off a single larger feed tube close to the machine, with each individual cartride being fed by an individual feed tube.

Conversely, multiple cartridges in multiple machines can be fed from a single large reservoir, such as multiple printers grouped in a row in a central printer location, e.g., in a law firm, grapics or print shop, publications department of a company, educational institution, government office or the like.

It should be understood that various modifications within the scope of this invention can be made by one of ordinary skill in the art without departing from the spirit thereof. We therefore wish our invention to be defined by the scope of the appended claims as broadly as the prior art will permit, and in view of the specification if need be.

CLAIMS

1. An auxiliary ink feed system for ink jet printers, plotters, copiers, and fax machines employing ink jet ink cartridges of the type which include means for compensating for vacuum generated therein during operation, such as bladders, springs and/or vacuum relief valves, comprising in operative combination:

(a) an external auxiliary ink reservoir;

(b) an ink feed tube connectable to said reservoir at a first proximal end and to at least one ink jet cartridge at its distal end;

(c) means for connecting the proximal end of said tube to said at least one cartridge to provide ink feed to said cartridge in response to vacuum created within said cartridge during printing.

2. An auxiliary ink feed system as in Claim 1 wherein said ink feed means comprises a lay-flat tube assembly adherable to the bottom of said cartridge, which tube has an aperture in one wall thereof which may be cooperatively aligned with an opening to a vacuum relief valve or check valve associated with said cartridge to provide ink access to the cartridge through said valve.

3. An auxiliary ink feed system as in Claim 2 wherein said lay-flat tube is adhered to said cartridge by double-sided tape having an aperture therein which is coordinate with the aperture in the lay-flat tube and which forms a seal around said valve opening.

4. An auxiliary ink feed system as in Claim 3 wherein said ink feed tube assembly includes means for securing said tube to said printer housing to provide a loop of said ink feed tubing between said securing means and said cartridge, which loop is oriented so that said ink feed tube does not interfere with the travel of said cartridge during its reciprocating time movement during printing.

5. An auxiliary ink feed system as in Claim 4 which includes means for controlling the direction of flexure of said ink feed tube between said cartridge and said securing means on said housing.

6. An auxiliary ink feed system as in Claim 1 wherein said reservoir includes an outlet fitting adapted to engage a fitting on the proximal end of said ink feed tube assembly, which reservoir fitting includes a valve means which is openable upon connection with a corresponding fitting on the proximal end of said feed tube assembly.

7. An auxiliary ink feed system as in Claim 1 wherein said reservoir is a bag.

8. An auxiliary ink feed system as in Claim 7 wherein said reservoir bag is disposed within a protective box.

9. An auxiliary ink feed system as in Claim 8 wherein said box includes means to permit visual determination of the fill level of said reservoir.

10. An auxiliary ink feed system as in Claim 1 wherein said ink feed tube assembly includes an anti-kink feed coil assembly surrounding at least a portion of said ink feed tube.

11. An auxiliary ink feed system as in Claim 1 wherein said ink feed means includes a foot plate assembly having an internal conduit terminating in an aperture disposed to cooperatively align with an opening to a vacuum relief valve or check valve associated with said cartridge to provide ink access to the cartridge through said valve.

12. An auxiliary ink feed system as in Claim 11, wherein said foot plate assembly includes double-sided tape to sealingly adhere said foot plate to said cartridge around said valve opening.

13. An auxiliary ink feed system as in Claim 1 which includes in said reservoir means to retain ink by capillary action.

14. An auxiliary ink feed system as in Claim 13 wherein said capillary means includes a sponge, open cell foam, felting, microfibers, or bead means to retain ink.

15. An auxiliary ink feed system as in Claim 1 wherein a plurality of said reservoirs are employed with ink feed tubes connected to a plurality of cartridges in the same or different machines.

16. An auxiliary ink feed system as in Claim 15, wherein a plurality of cartridges are fed from a single reservoir.

17. An auxiliary ink feed system as in Claim 15 wherein each reservoir is dedicated to a specific color and each of which includes an ink delivery tube assembly to individual cartridges corresponding to said ink color.

18. An auxiliary ink feed system as in Claim 17 which includes three to ten reservoirs, individual ones being dedicated to inks selected from the colors of black, magenta, cyan, green, orange, yellow and determined spot color(s).

19. An auxiliary ink feed system as in Claim 2 wherein said lay-flat tube includes internal ribs or bag spreader anti-collapse elements.

20. An auxiliary ink fed system as in Claim 1 which includes a check valve in communication with said reservoir.

21. An auxiliary ink fed system as in Claim 12 which includes a vacuum relief valve in communication with said reservoir.

22. An auxiliary ink feed system as in Claim 1, wherein said reservoir includes an outlet fitting adapted to piercingly engage a soft polymeric disc-type plug in a fitting of said proximal end of said ink feed tube, said plug providing a seal between said reservoir and said feed tube fittings.

23. An auxiliary ink feed system as in Claim 1, wherein said distal connector includes a hollow needle insertable into an air port in said cartridge and through a bladder assembly diaphragm,

and which includes means to permit escape of air from said cartridge during filling of ink from said reservoir.

24. An auxiliary ink feed system as in Claim 11, wherein said foot plate assembly includes a tubular projection connected to said internal conduit for pushing a ball plug into said cartridge.

25. A method for auxiliary feed of ink to ink jet printers, plotters, copiers, and fax machines which machines have cartridges, of the type which include means for compensating for vacuum generated therein during operation, such as bladders, springs, and/or vacuum relief valves comprising the steps of:

(a) providing an external reservoir and an ink delivery system introduceable into said cartridge;

(b) feeding ink to said cartridge through an aperture in said cartridge so that said ink is fed from said reservoir at least in part by negative pressure generated in said cartridge upon and in relation to printing, rather than wholly from gravity feed generated external to said cartridge.

26. A method of auxiliary ink feed as in Claim 25, wherein said feed is via a vacuum relief valve, a check valve or an air port in said cartridge.

27. A method of auxiliary ink feed as in Claim 25 which includes the steps of:

(a) securing said reservoir to a support surface or to the side of said printer; and

(b) securing said ink feed tube to said printer so that said ink feed includes a loop oriented so the ink feed tube is oriented to not interfere with the travel of said cartridge during its reciprocating movement during printing.

28. A method of auxiliary ink feed as in Claim 25 which includes providing at least one reservoir, and feeding ink from said reservoir to a plurality of cartridges in the same or different machines.

29. A method of auxiliary ink feed as in Claim 28 wherein each reservoir is dedicated to a separate color, each of which is dedicated to a corresponding color of print cartridges.

30. A method of auxiliary ink feed as in Claim 27, wherein each reservoir feeds a plurality of print cartridges in a single machine.

31. A method of auxiliary ink feed as in Claim 25 which includes the step of providing the auxiliary ink feed system as a kit in which the ink feed line is not primed.

32. A method of auxiliary ink feed as in Claim 25 wherein said auxiliary ink reservoir is a bag, and which includes the step of providing a protective box in which said bag is disposed having means for mounting said box to said printer or a surface adjacent to said printer.

33. A method of auxiliary ink feed as in Claim 25, wherein said ink delivery system includes an ink feed tube from said

reservoir and a connector at the distal end thereof adapted to feed ink to said cartridge in response to vacuum generated in said cartridge during printing, said connector being selected from a lay-flat tube, a foot-plate or a check-valve-and-port-seal assembly.

34. A method of auxiliary ink feed as in claim 25, wherein said ink delivery system includes an ink feed tube from said reservoir and a hollow fill needle insertable into an air port of said cartridge and through a bladder assembly diaphragm, and which includes means to permit escape of air from said cartridge during filling ink from said reservoirs.

35. An ink fill station for loading ink jet printer cartridges having at least one internal bladder or spring bag which includes in operative combination:

a) means for retaining said cartridge during fill operation;

b) means for inflating said bladder through a port in said cartridge in communication with said bladder;

c) means for sealingly engaging a vacuum relief valve of said cartridge in fluid communication with a reservoir of ink; and

d) means for releasing said inflation of said bladder while retaining said valve sealed to permit filling said cartridge during deflation of said bladder to permit inlet of ink into the ink-retaining volume of said cartridge.

36. An ink fill station as in Claim 35, wherein said cartridge retaining means retains said cartridge in an inverted portion.

37. an ink fill station as in Claim 35, wherein said port is an air port and said bladder is inflated by positive gas pressure supplied through said air port.

38. An ink fill station as in Claim 35, wherein said port is said vacuum relief valve, and said bladder is inflated by generating negative pressure in said cartridge by vacuum draw through said vacuum relief value.

39. A method of filling an ink jet cartridge having at least one internal bladder or spring bag comprising in any operative sequence the steps of:

a) retaining said cartridge during fill operation;

b) inflating said bladder;

c) establishing fluid communication between the ink-retaining volume of said cartridge with an external ink reservoir through a vacuum relief valve of said cartridge;

d) deflating said bladder to draw ink from said reservoir through said valve into said ink-retaining volume.

40. A method of filling an ink jet cartridge as in Claim 39, wherein said inflating step includes pressurizing said bladder with gas pressure through an air port in communication with said bladder.

41. A method of filling an ink jet cartridge as in Claim 39, wherein said inflating step includes generating negative pressure in said cartridge by vacuum draw through said vacuum relief valve.

42. A method for mounting a feed tube from an auxiliary ink tank to a printer, plotter, copier, or fax ink jet ink cartridge of a type having a vacuum relief valve or bubble generator comprising the steps of:

(a) positioning an ink delivery means having an aperture therein sized to substantially surround the vacuum relief valve or bubble generator opening into cooperative alignment of said aperture with said opening; and

(b) securing said ink delivery means of said cartridge in cooperative alignment with said opening to permit ink feed by vacuum draw from said ink delivery means through said valve or bubble generator.

43. An auxiliary ink feed system for printing machines having ink jet cartridges comprising in operative combination:

(a) an external auxiliary ink reservoir;

(b) an ink feed tube having connector means for connecting said tube at one end to said reservoir, and to at least one ink cartridge at said other end;

(c) said connector means at said ink cartridge end of said feed tube is adapted to be sealingly secured to said cartridge to feed ink thereunto through a hole provided therein; and

(d) a check valve disposed in association with said reservoir or said ink feed line to maintain proper vacuum draw of ink from said reservoir.

44. An auxiliary ink feed system as in claim 43, wherein said reservoir includes a vacuum relief valve in functional association therewith.

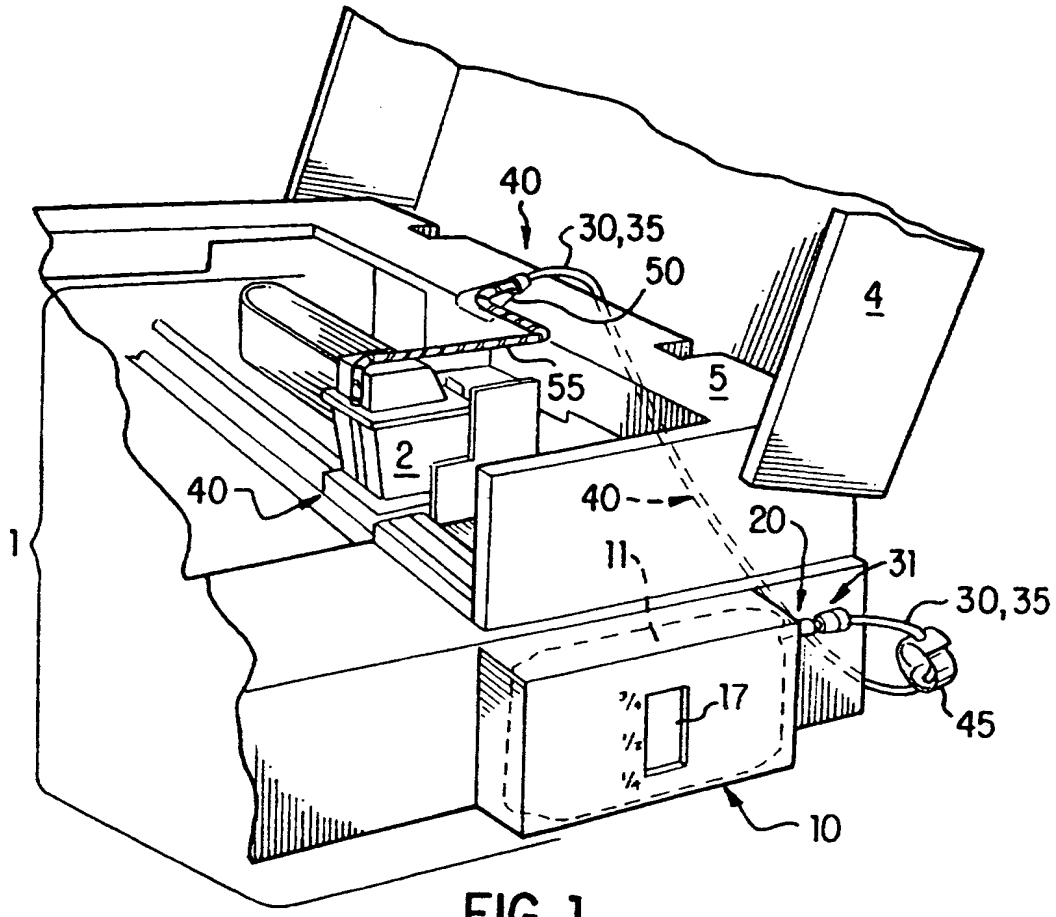

FIG. 1

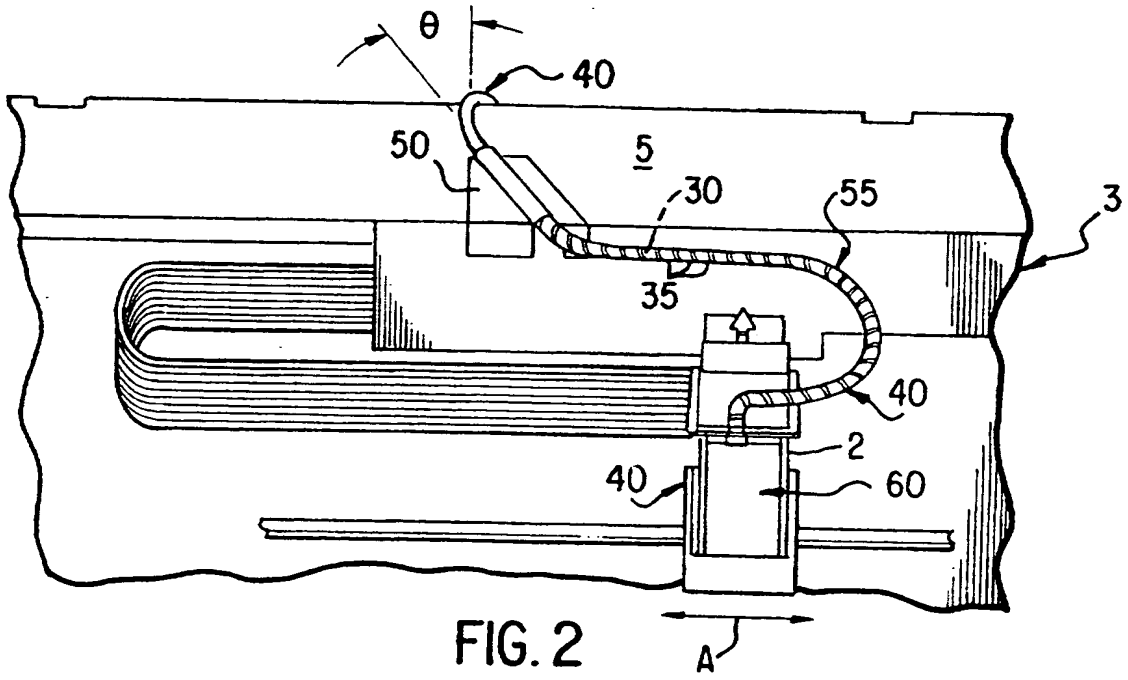

FIG. 2

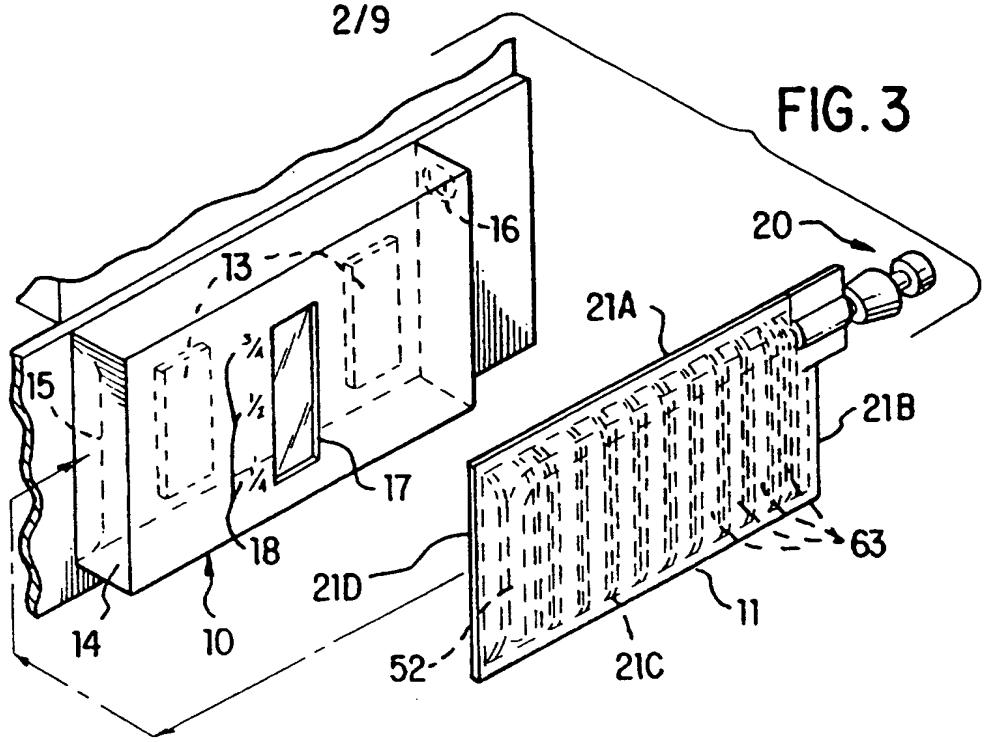

FIG. 3

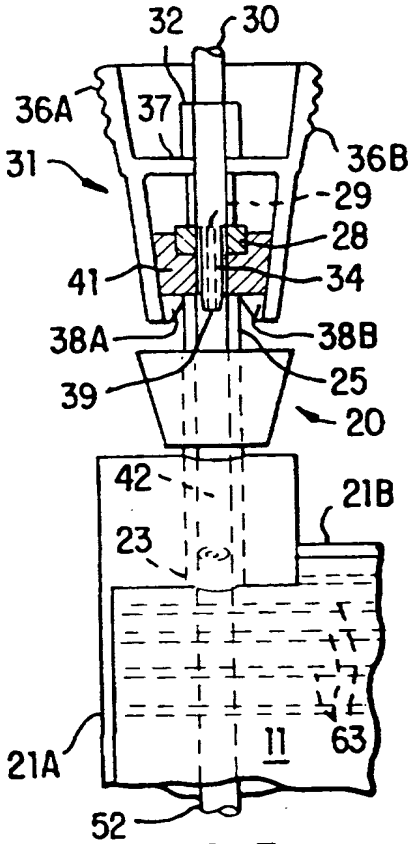

FIG. 5

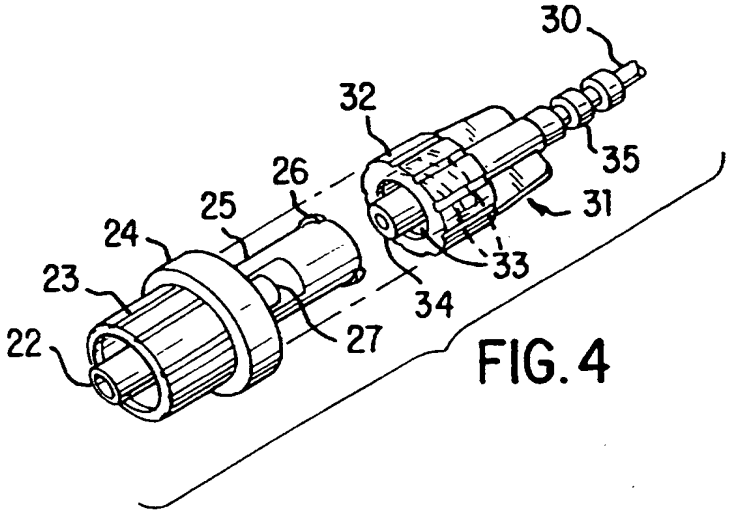

FIG. 4

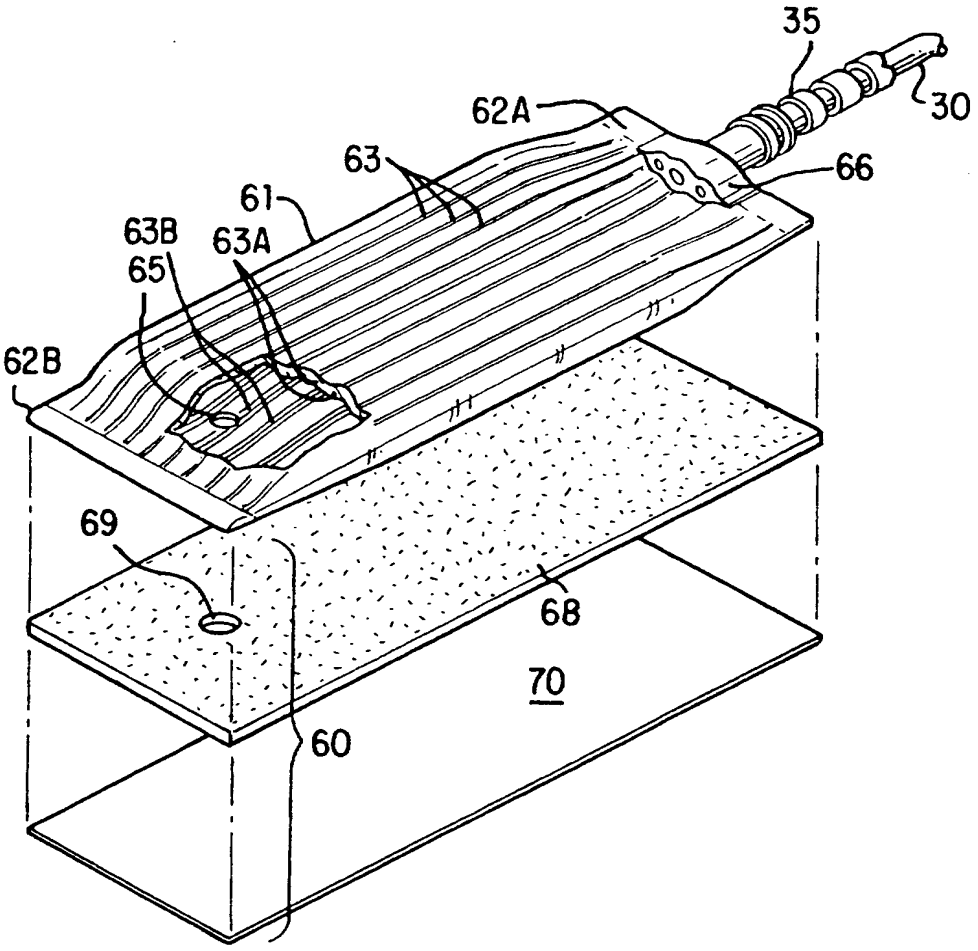

FIG. 6

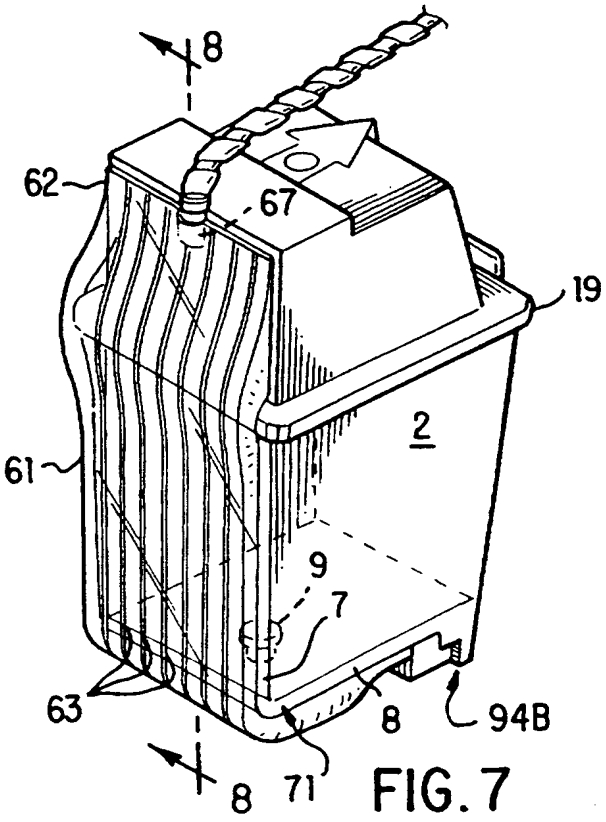

FIG. 7

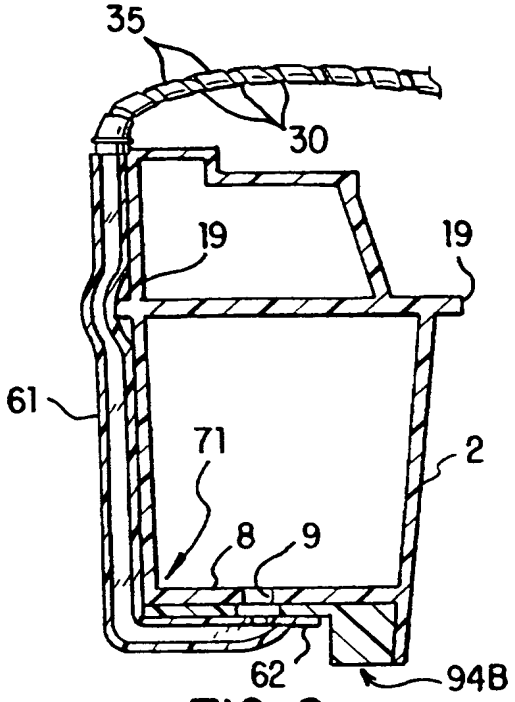

FIG. 8

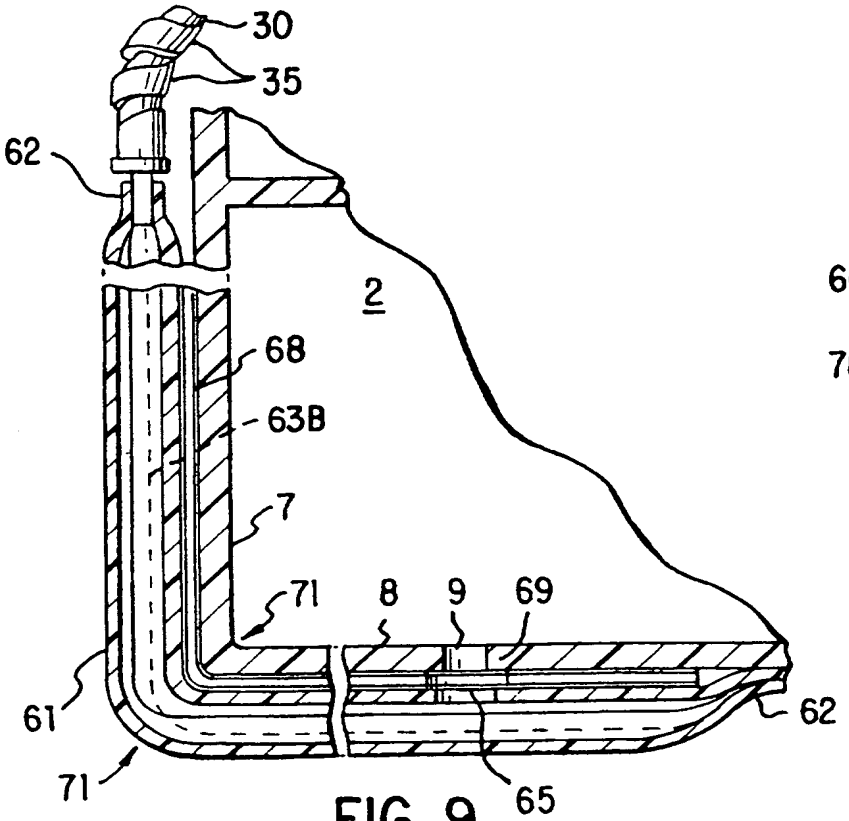

FIG. 9

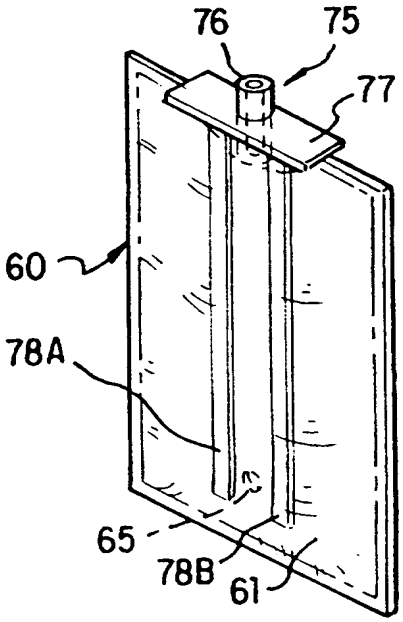

FIG. 10

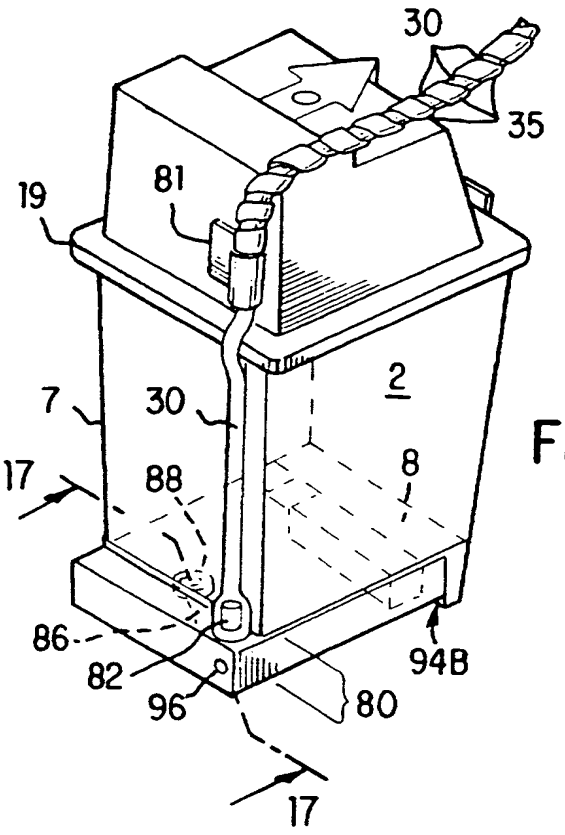

FIG. 11

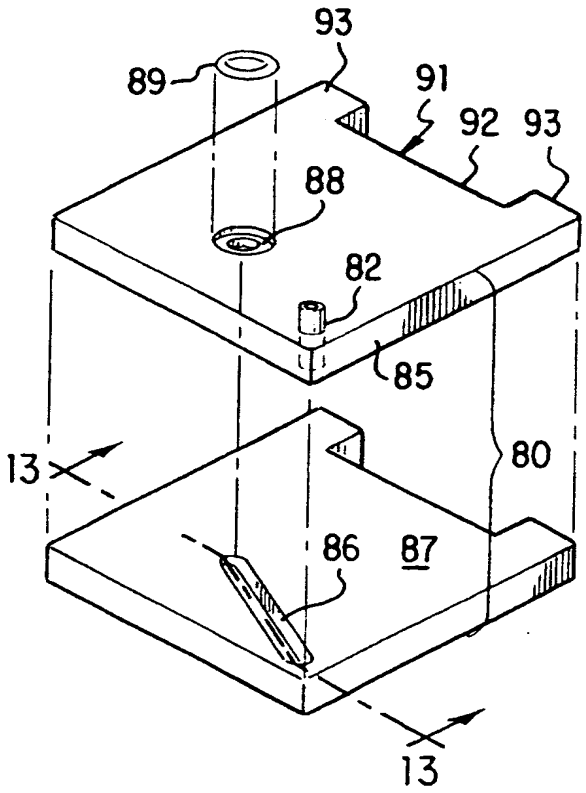

FIG. 12

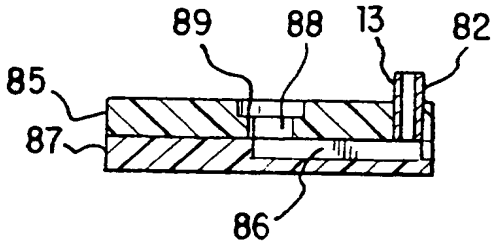

FIG. 13

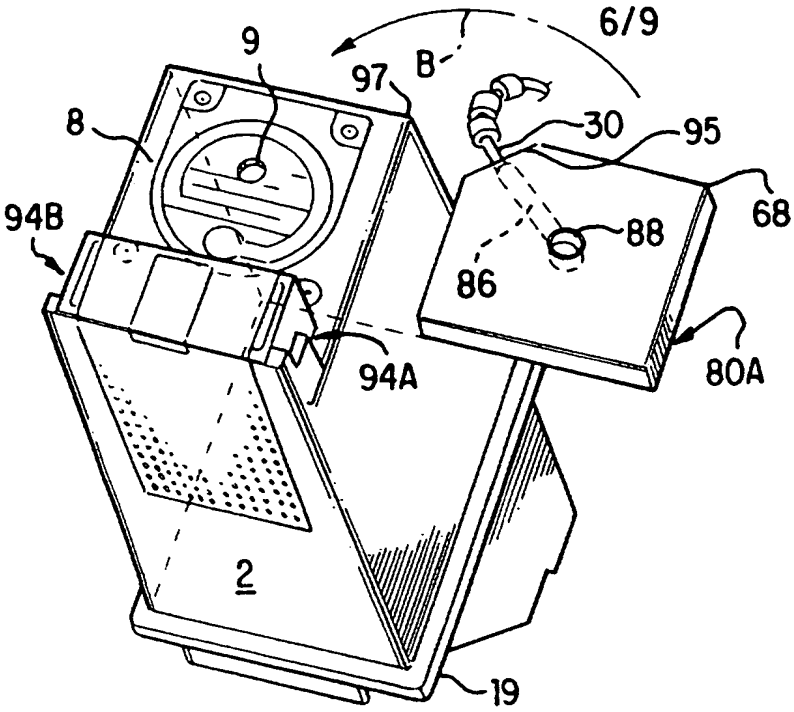

FIG. 14

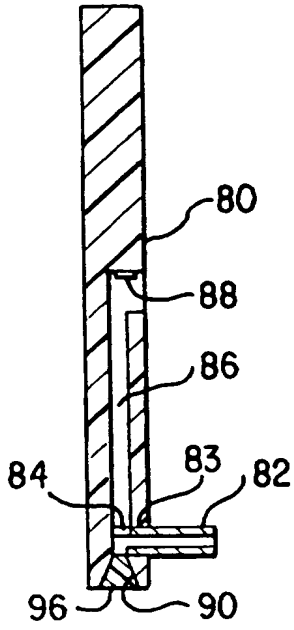

FIG. 17

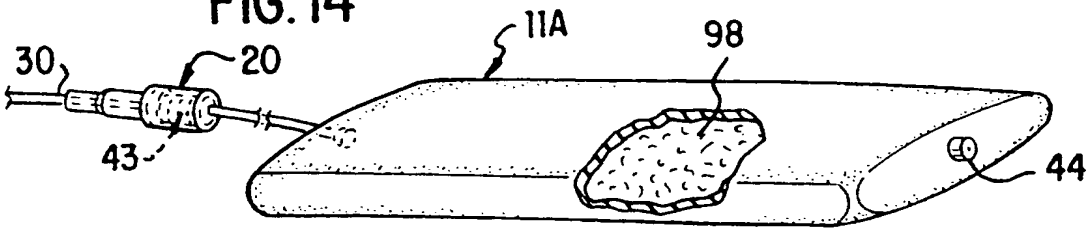

FIG. 15

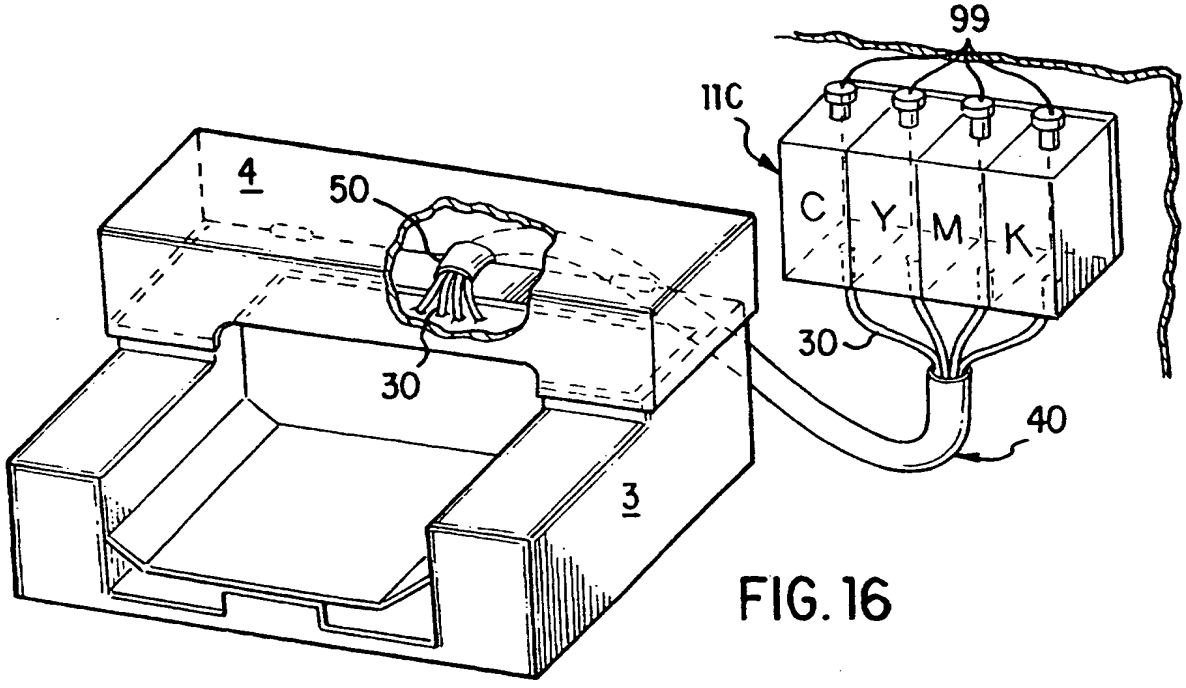

FIG. 16

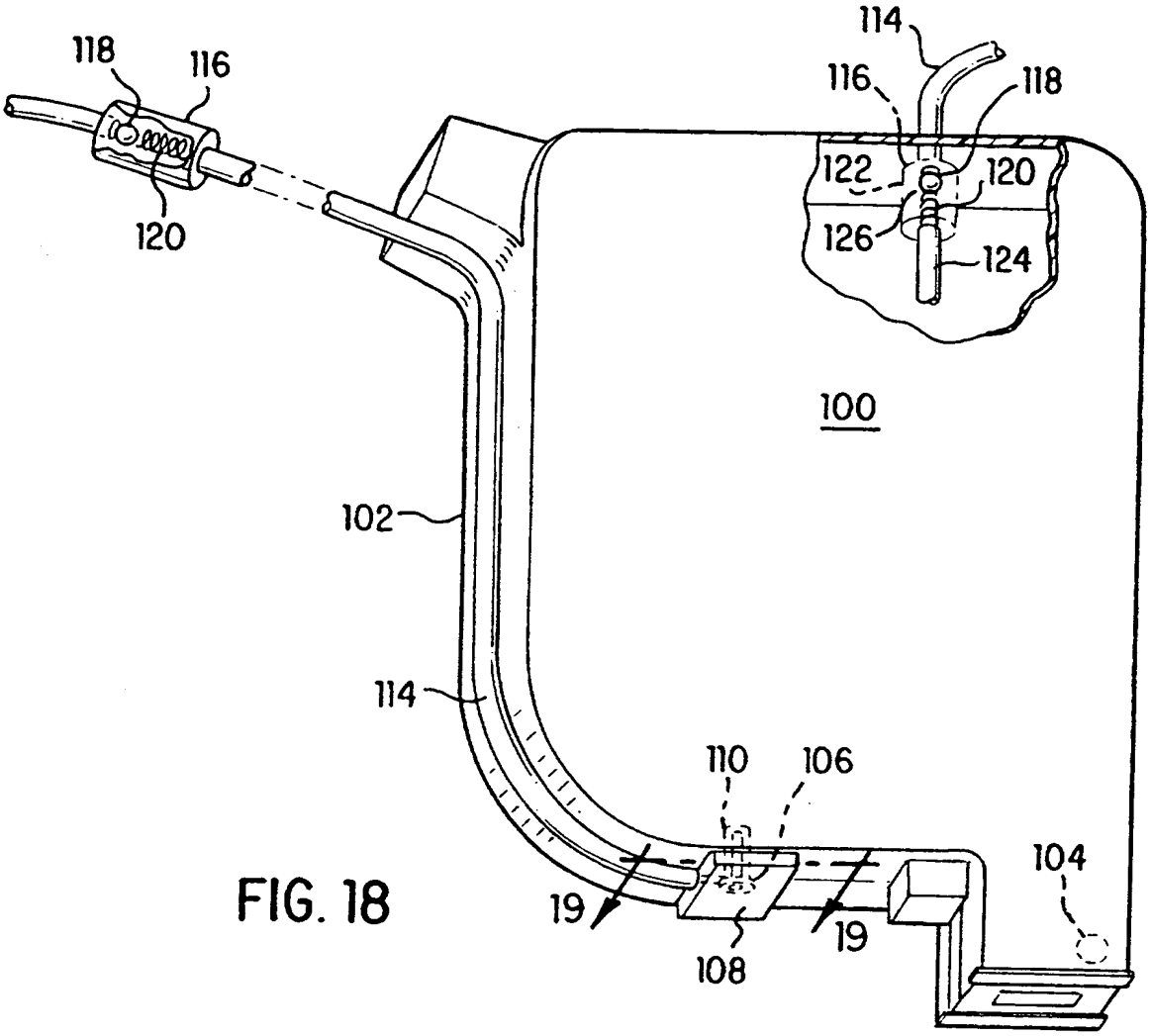

FIG. 18

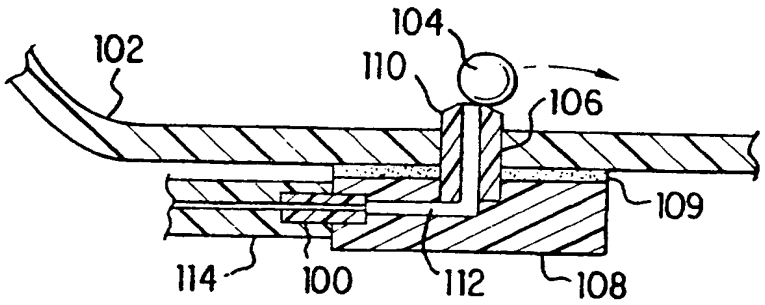

FIG. 19

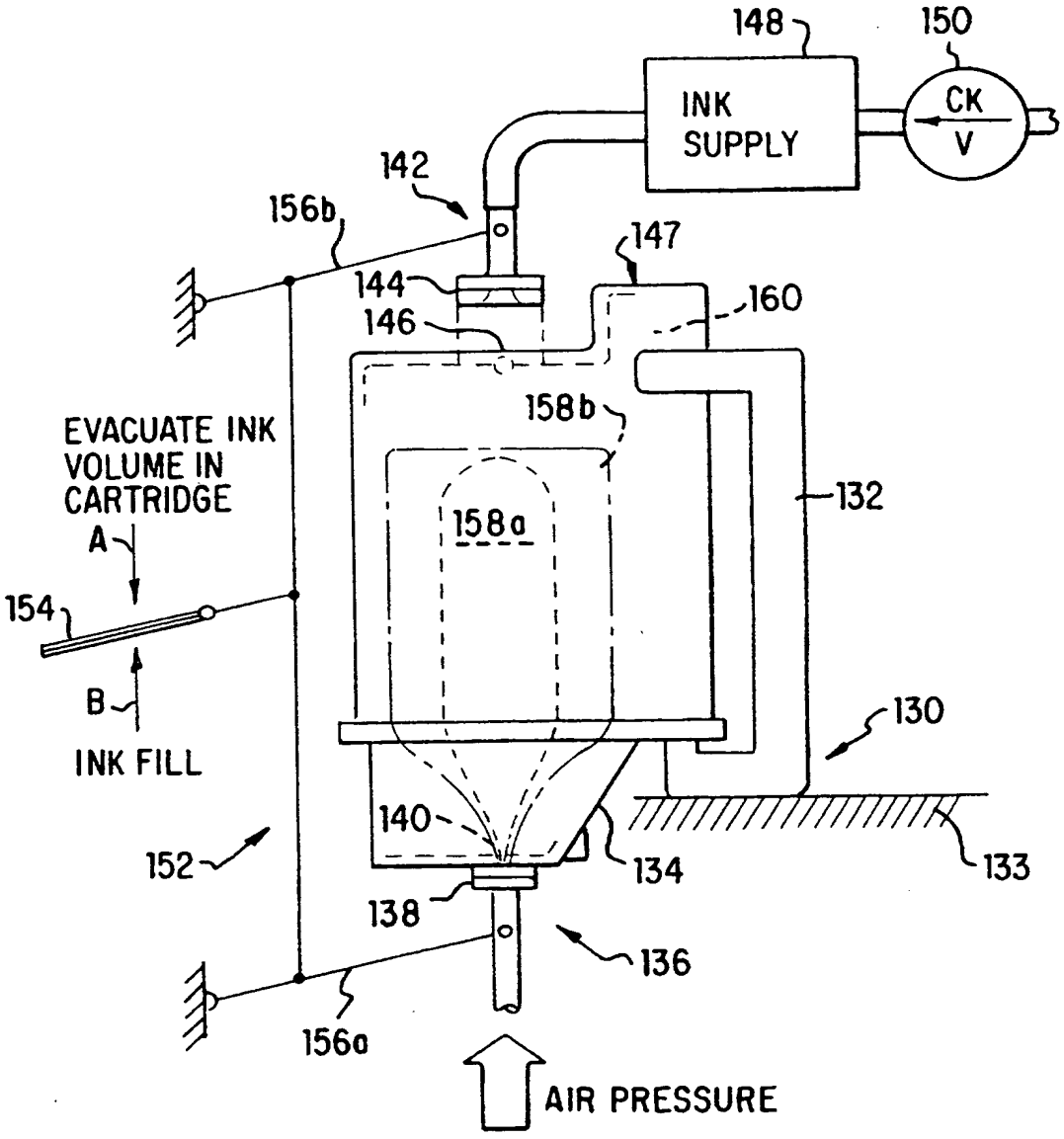

FIG. 20

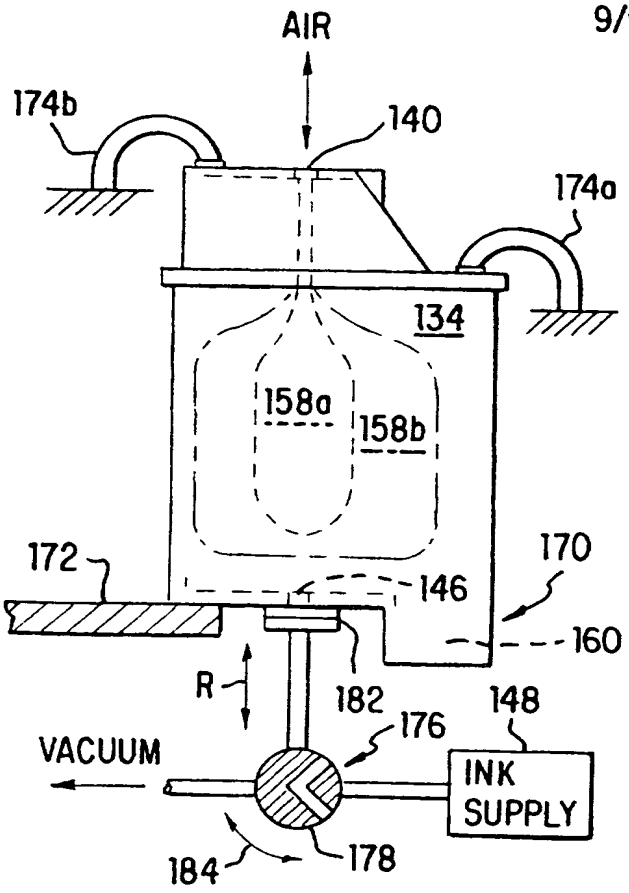

FIG. 21

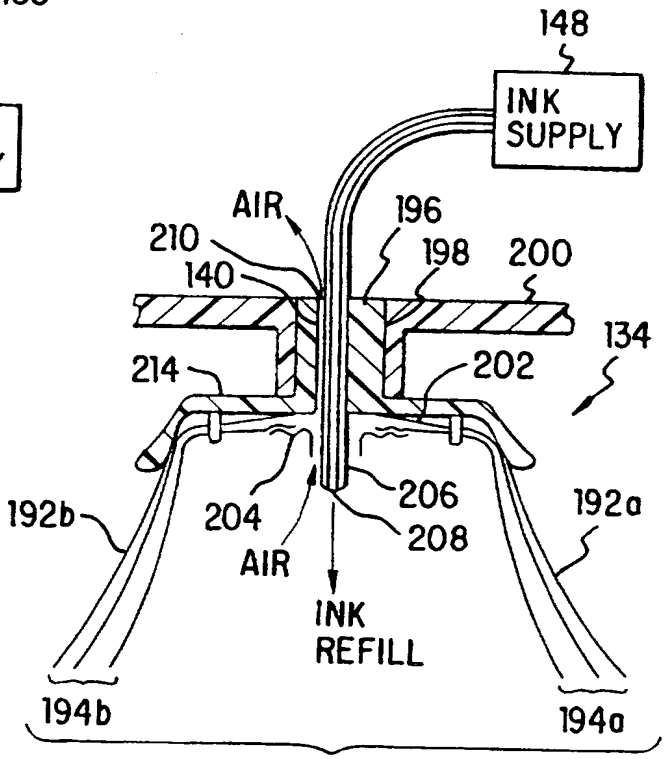

FIG. 22

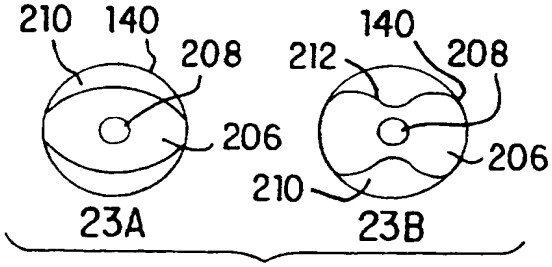

FIG. 23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07126

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B41J 2/175
US CL :347/86

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 138/118, 177, 178; 347/71, 85, 86, 87

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,280,300 A (FONG et al.) 18 January 1994, see entire doc.	1, 20, 25, 31, 42, 43,
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Y		2-14, 15-19, 21-24, 26-30, 32-34, 44
Y	IBM Tech. Dis. Bull. February 1973. Vol. No. 9. page 2898	6, 26
Y	US 5,367,328 A (ERICKSON) 22 November 1994, see entire doc.	4, 5, 7-9, 15-18, 27-30, 32
Y	US 4,935,751 A (HAMLIN) 19 June 1990, column 3, line 26	9

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 24 JUNE 1997	Date of mailing of the international search report 16 JUL 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JUDY NGUYEN Telephone No. (703) 305-7062

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07126

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 61-63455 A (SAITO) 01 April 1986, CONSTITUTION, see last 4 lines	10
Y	US 4,599,628 A (DORING et al) 08 June 1986, see entire doc.	11-13, 21, 24
Y	US 5,235,352 A (PIES et al) 10 August 1993, column 7, line 61	3-5, 12, 21
Y	US 5,400,573 A (CRYSTAL et al) 28 March 1995, see entire doc.	24
Y	US 5,500,663 A (UJITA et al) 19 March 1996, column 20, lines 6-22	21, 44
Y	US 5,119,115 A (BUAT et al.) 02 June 1992, column 3, lines 55-66	13, 14
Y	JP 62-161544 A (MUNEHIRO) 17 July 1987, CONSTITUTION, last 6 lines	22
Y	US 3,889,717 A (OBADAL et al.) 17 June 1975, see entire doc.	2-5, 19
Y	US 5,537,134 A (BALDWIN et al) 16 July 1996, see entire doc.	23, 33-41
Y	US 5,136,305 A (IMS) 04 August 1992, see column 3, lines 33-65	35-41
Y	US 5,453,772 A (AONO et al) 26 September 1995, column 3, lines 12-21	37
Y	US 4,422,084 A (SAITO et al) 20 December 1983, column 5, lines 1-38	38-41

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07126

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07126

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-34, 43 & 44, drawn to an auxiliary ink feed system.
Group II, claims 35-41, drawn to an ink fill station.
Group III, claim 42, drawn to a method for mounting a feed tube from an auxiliary ink tank to a printer.

The inventions listed as Groups I-III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: Group I is directed to a continuous feeding system from an auxiliary reservoir during printing operation. Group II is directed to a filling of a cartridge at a filling station during non-printing state, and Group III is directed to mounting of a feed tube only.